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WHAT'S NEW IN INTENSIVE CARE

Preventing ventilator-associated pneumonia non-pharmacologically

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In critically ill, intubated patients on intensive care unit (ICU), ventilator-associated pneumonia (VAP) is a significant complication contributing to substantial mortality, morbidity, and prolonged stays, which in turn requires considerable financial and natural resources [1, 2]. Preventing VAP is therefore essential for improving patients' safety and enhancing the outcomes' cost-effectiveness and sustainability of healthcare [1].

Herein, we summarize the evidence for preventing VAP by non-pharmacological interventions, based on a systematic literature research of the ongoing update of the Clinical Treatment Guideline on Invasive Ventilation and Extracorporeal Gas Exchange in Acute Respiratory Insufficiency under the direction of the German Society for Anaesthesiology and Intensive Care Medicine (DGAI).

Non-pharmacological measures to prevent VAP have been extensively studied. Establishing a s urveillance system with a consistent definition, an infection control team, and regular feedback to the staff have proven effective in reducing nosocomial infections, including VAP [1]. However, recent evidence is scarce, partly because the lack of a rigorous definition and surveillance system hampers the assessment of other interventions' effectiveness. Basically, strictly indicating and maintaining invasive ventilation as short as possible, followed by evidence-based VAP-prevention bundles, should build the daily basis of critical care. Enhanced hand hygiene compliance has been associated with reduced VAP rates and should be mandatory because of avoiding VAP [3]. Elevating the upper body of invasive ventilated patients is another effective strategy to reduce the risk of micro aspirations and VAP, particularly when the semi-recumbent position (45° elevation) is used. Prone position might reduce VAP rates compared to the supine position, although likely to a lesser extent and with inconclusive evidence. However, the prone position has demonstrated a more significant reduction in mortality in patients with acute respiratory distress syndrome. High-quality randomized controlled trials with the end point VAP rate are lacking, so there could be no general recommendation in the context of VAP prophylaxis. Of course, prone positioning remains a hallmark in the therapy of moderate to severe acute respiratory distress syndrome [4, 5]. Endotracheal tubes (ETT) with subglottic secretion drainage, designed to remove secretions above the cuff that can cause VAP via micro aspiration, have shown a significant reduction in VAP rates in meta-analyses [6]. Bundling various VAP prevention measures has been shown to reduce mortality by approximately 10% [7].

Several interventions are not recommended based on current evidence. Tapered cuffs proposed to prevent micro aspiration did not show a significant effect on VAP rate compared to conventionally shaped cuffs [8], nor did polyurethane cuffs compared to polyvinylchloride cuffs [9]. Continuous cuff monitoring and physiotherapy also failed to demonstrate certain impacts on VAP rates or ICU mortality [10]. Although silver-coated endotracheal tubes and tracheal saline instillation significantly reduced VAP rates, they were associated with a trend toward higher mortality [10], possibly due to biased pathogen detection. The lateral Trendelenburg position has demonstrated a slight reduction in VAP rates in the post hoc analysis of one trial; however, it cannot be generally recommended based on current evidence due to a significantly higher incidence of serious adverse effects, particularly temporary oxygen desaturation and hemodynamic instability [11]. In several older studies, mostly of low methodological quality, the use of kinetic beds led to

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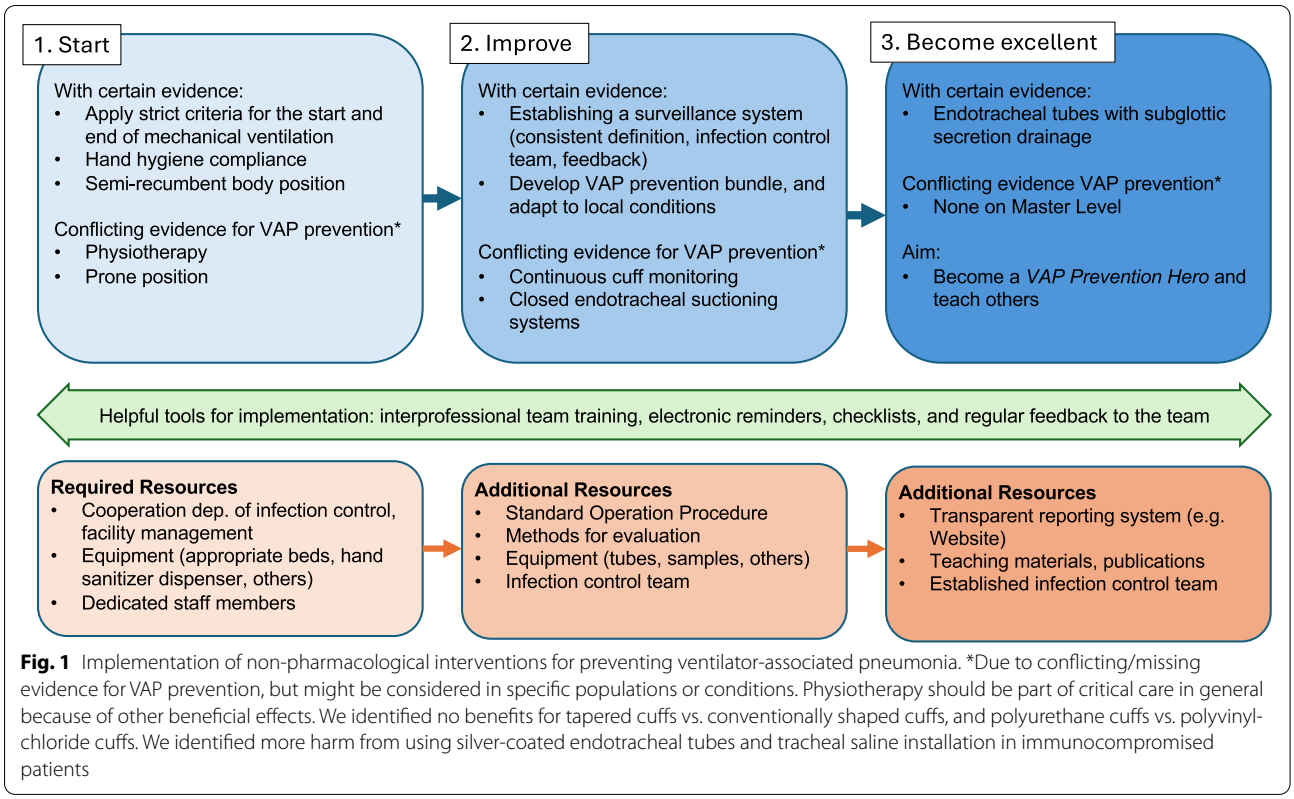
1. Start
With certain evidence:
• Apply strict criteria for the start and end of mechanical ventilation
• Hand hygiene compliance
• Semi-recumbent body position
Conflicting evidence for VAP prevention*
• Physiotherapy
• Prone position
2. Improve
With certain evidence:
• Establishing a surveillance system (consistent definition, infection control team, feedback)
• Develop VAP prevention bundle, and adapt to local conditions
Conflicting evidence for VAP prevention*
• Continuous cuff monitoring
• Closed endotracheal suctioning systems
3. Become excellent
With certain evidence:
• Endotracheal tubes with subglottic secretion drainage
Conflicting evidence VAP prevention*
• None on Master Level
Aim:
• Become a VAP Prevention Hero and teach others
Helpful tools for implementation: interprofessional team training, electronic reminders, checklists, and regular feedback to the team
Required Resources
• Cooperation dep. of infection control, facility management
• Equipment (appropriate beds, hand sanitizer dispenser, others)
• Dedicated staff members
Additional Resources
• Standard Operation Procedure
• Methods for evaluation
• Equipment (tubes, samples, others)
• Infection control team
Additional Resources
• Transparent reporting system (e.g. Website)
• Teaching materials, publications
• Established infection control team

Fig. 1 Implementation of non-pharmacological interventions for preventing ventilator-associated pneumonia. *Due to conflicting/missing evidence for VAP prevention, but might be considered in specific populations or conditions. Physiotherapy should be part of critical care in general because of other beneficial effects. We identified no benefits for tapered cuffs vs. conventionally shaped cuffs, and polyurethane cuffs vs. polyvinyl-chloride cuffs. We identified more harm from using silver-coated endotracheal tubes and tracheal saline installation in immunocompromised patients

a reduction in VAP rates [12]. However, more recent and high-quality studies on this topic are lacking.

Closed endotracheal suctioning systems, while demonstrating a statistically significant association with VAP reduction, have conflicting evidence regarding their overall efficacy, particularly as they do not show a reduction in mortality and are associated with a high risk of bias in the studies, especially due to the impossibility of blinding [10, 13].

There is significant variability in the definitions of VAP used across studies, which complicates the comparison and generalization of findings. This inconsistency undermines the ability to assess the true effectiveness of interventions, as the outcomes are measured against differing criteria. Additionally, the lack of blinding in some interventions (e.g., body positioning, special endotracheal tubes, etc.) introduces a high risk of bias, which can affect the reliability of the results. For instance, interventions like closed endotracheal suctioning systems, while associated with reduced VAP rates, may have overestimated benefits due to study design limitations.

A central approach of caring for the critical ill patient is avoiding harmful interventions, so the use of tracheal saline instillation and silver-coated endotracheal tubes, despite some evidence of VAP reduction, carries potential risks, especially in these vulnerable patient population and so should be strictly avoided. Furthermore, every procedure for preventing VAP should be considered for the needed resources and the barriers of implementation.

Barriers to implementation often include limited staff resources and time constraints, as well as specific local challenges. To address these barriers, we recommend developing a VAP prevention bundle tailored to local conditions (Fig. 1). Effective strategies may include team training, electronic reminders, checklists, and regular feedback to the team [17]. A VAP surveillance system and consistent hand hygiene compliance should be standard practices, as they are easily implemented and serve as quality indicators. Elevating the patient's body position, unless contraindicated, is a low-resource measure with sufficient evidence to prevent VAP. Also, subglottic secretion drainage has shown evidence to prevent VAP at least in patients requiring ventilation lasting several days. Other prevention measures may be necessary in specific settings or for certain populations. In future VAP studies, further non-pharmacological interventions should be considered, such as early mobilization, targeted nutrition therapy, appropriate nurse–patient ratios, and interprofessional communication. These have been widely studied and show promising benefits, though their direct impact on reducing VAP outcomes remains uncertain.

Until more robust evidence is available, the multidisciplinary team should carefully select prevention measures. Given these challenges, further high-quality, (cluster) randomized controlled trials are crucial to establish the effectiveness of VAP prevention interventions. These studies should aim for consistent VAP definitions, rigorous methodologies to minimize bias, and consideration of the heterogeneity in patient populations and clinical settings, ultimately improving patient safety, survival, and quality of life after critical care.

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Data availability
All data of this review are reported in the manuscript.

Declarations

Conflicts of interest
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Ethical approval
No ethic approval is required for this work.

Statement on the use of artificial intelligence (AI) in the writing process
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